



NASA SBIR 2012 Phase I Solicitation

A3.08 Propulsion Efficiency - Turbomachinery Technology

Lead Center: GRC

There is a critical need for advanced turbomachinery and heat transfer concepts, methods and tools to enable NASA to reach its goals under the Fundamental Aeronautics Program. These goals include dramatic reductions in aircraft fuel burn, noise, and emissions, as well as an ability to achieve mission requirements for, Subsonic, Rotary Wing, and High Speed Project flight regimes and fundamental research under the Aeronautical Sciences Project. Turbomachinery includes rotating machinery in the high and low pressure spools, transition ducts, purge and bleed flows, casing and hub. In the compression system, advanced concepts and technologies are required to enable higher overall pressure ratio, high stage loading and wider operating range while maintaining or improving aerodynamic efficiency. Such improvements will enable reduced weight and part count, and will enable advanced variable cycle engines for various missions. In the turbine, the very high cycle temperatures demanded by advanced engine cycles place a premium on the cooling technologies required to ensure adequate life of the turbine component. Reduced cooling flow rates and/or increased cycle temperatures enabled by these technologies have a dramatic impact on the engine performance.

Proposals are sought in the turbomachinery and heat transfer area to provide the following specific items:

- Advanced instrumentation to enable time-accurate, detailed measurement of unsteady velocities, pressures and temperatures in three-dimensional flowfields such as found in turbomachinery components and transition ducts. This may include instrumentation and measurement systems capable of operating in conditions up to 900 °F and in the presence of shock-blade row interactions, as well as in high speed, transonic cascades. The instrumentation methods may include measurement probes, non-intrusive optical methods and post-processing techniques that advance the state-of-the-art in turbomachinery unsteady flowfield measurement for purposes of accurately resolving these complex flowfield. Instrumentation enabling measurements and characterization of unsteady turbulent flows at combustor exit temperatures that can be implemented in warm test rigs and actual engines is also included. Instrumentation specific to turbomachinery and heat transfer should be proposed under this subtopic.
- Advanced turbomachinery active and passive flow control concepts to enable increased high stage loading in single and multi-stage axial compressors while maintaining or improving aerodynamic efficiency and operability. Technologies are sought that would reduce dependence on traditional range extending techniques (such as variable inlet guide vane and variable stator geometry) in compression systems. These may include flow control techniques near the compressor end walls and on the rotor and stator blade surfaces. Technologies are sought to reduce turbomachinery sensitivity to tip clearance leakage effects where clearance to chord ratios may be on the order of 5% or above. Technologies are sought to eliminate

flow separation in low pressure turbines and transition ducts, improve off-design operation and enable variable cycle operation.

- Novel turbine cooling concepts are sought to enable very high turbine cooling effectiveness especially considering the manufacturability of such concepts. These concepts may include film cooling concepts, internal cooling concepts, and innovative methods to couple the film and internal cooling designs. Concepts proposed should have the potential to be produced with current or forthcoming manufacturing techniques. The availability of advanced manufacturing techniques may actually enable improved cooling designs beyond the current state-of-the-art. Concepts are also sought for the cooling of ceramic-based turbine materials such as ceramic matrix composite (CMC) vanes and blades.
- Computational technologies allowing accurate predictions of turbomachinery flows and heat transfer including active and passive flow control features. Advanced turbulence and LES models that can account for complex three-dimensional flows common in turbomachinery. Models of flow control devices that enable incorporating them in RANS based CFD codes. Particular interest is in CFD method based on overset moving grids that will enable flexibility in studies of small features as cooling holes and active and passive flow control devices.